V regions be upstream of the *C* regions (if they were downstream, the *C* region itself would become part of the deleted DNA).

For a *V* region to be downstream of the *C* region, topological considerations dictate that the *V* region must be in opposite transcriptional orientation to the *C* region. Malissen *et al.* were able to verify this because the *V* and *C* regions are near enough to each other to be physically linked in cloned DNA. The structure that they uncovered, in fact, implies that the joined segment in the T-cell clone arose by an initial deletional join of an upstream *D* segment to a *J* segment followed by a *V*-to-*D* – *J* inversional join in the downstream direction.

It should be emphasized that all of the DNA mechanics that have been found to underlie T-cell receptor gene rearrangement are congruent to the events of immunoglobulin gene rearrangement. The DNA signals thought to direct the rearrangement process are indistinguishable in the two systems. Malissen *et al.* reinforce this perspective by showing that *D*-to-*J* rearrangement precedes *V*-to-*D* – *J* rearrangement as found for immunoglobulin heavy chains. They also note that the joined genes have lost potential coding nucleotides found near the joining signals in the germline DNA elements and that new nucleotides (constituting an *N* region) are found between the joined *V* and *D* segments. The only surprise is that the reciprocal joint formed during the recombination retains three nucleotides between the heptamers. In all cases of immunoglobulin gene joining yet studied, the heptamers are joined back-to-back with no intervening nucleotides (in one case a join with one nucleotide missing was found; ref. 9).

With this demonstration of inversional joining of a T-cell receptor *V* gene segment, most of what we want to know about the topology of joining is available. All we now need is to understand the sequence requirements for joining; then we can turn to enzymology, a task already begun in many laboratories but with little reported success. ☐

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100 years ago

PHYSICS AT JOHNS HOPKINS

The large and well appointed laboratories recently erected by the Trustees of the Johns Hopkins University for the Chemical and Biological Departments have by contrast made the more evident the needs of the Physical Department, which has been obliged to occupy temporarily parts of four different buildings for a physical laboratory. The new laboratory is to be a handsome building of red brick, trimmed with brown sandstone, and will occupy a fine site about a block from the other University buildings, on the corner of a quiet little street midway between the more important streets, which carry the bulk of the traffic. It will therefore be as free from disturbance from the earth-vibrations as could be expected in a city. The building will be 115 feet long by 70 feet broad, and will have four stories besides the basement. In the centre of the building, and below the basement, are several vaults for instruments requiring to be used at constant temperature, also a fireproof vault for storage. In these vaults will be placed Prof. Rowland's dividing-engine, by which the diffraction-gratings are ruled, and the Rogers-Bond comparator, which has recently become the property of the University. There will be a tower on the south-east corner which will be provided with telescope and dome, and will be a convenient observatory when great steadiness in the instruments is not required.

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Plate tectonics

Global thermal histories

from Mike Bickle

TECTONIC geology is a manifestation of the thermal evolution of the interior of the Earth. Surprisingly, models for this thermal evolution have proved difficult to reconcile with a geological record that extends over three-quarters of the history of the Earth. The relatively low crustal thermal gradients recorded in the earliest rocks are incompatible with the higher gradients predicted by convection models that incorporate the higher radiogenic heat production that must have then prevailed. After re-examining this problem, F.M. Richter (*Earth planet. Sci. Lett.* **73,** 350; 1985) concludes that low continental thermal gradients could only have been maintained in the Archaean if the continental lithosphere was stabilized by chemical means (that is, was less dense), rather than being a simple thermal boundary layer as seems appropriate for much of the present-day lithosphere. The concept of a chemically stabilized lithosphere is not new (see, for example Jordan, T.H. *Nature* **274,** 544; 1978) but it now seems that such stabilization was of greater importance in the past and may have had a profound effect on the evolution and preservation of ancient continental crust.

Models for global thermal evolution allow calculation of the temperature dependence of heat loss for a spherical, layered and convecting Earth. To be successful, a model must not only yield a plausible range of present-day interior temperatures (given an appropriate initial state), but must also account for the higher radiogenic heat production and loss of initial heat formation that must have occurred in the past. Successful models achieve this by generating internal temperatures higher than at present and thinner boundary layers with steeper thermal gradients.

Good evidence for higher internal temperatures is provided by komatiitic lavas, which are restricted to the Archaean and were erupted at temperatures about 200°C higher than any recent lavas. However, the geological evidence from metamorphic rocks, crustal thickness and sedimentary basin subsidence indicates that the range of crustal thermal gradients in the Archaean may not have differed significantly from the range of modern continental thermal gradients. This inference is strongly supported by the demonstration of Archaean ages for diamonds (Richardson, S.H. *et al. Nature* **310,** 198; 1984). The diamonds must have been preserved since roughly 3,200 Myr ago at depths greater than 150 km in continental lithosphere of at least similar thickness to present day continental lithosphere.

The problem addressed by Richter is how to allow higher interior temperatures without affecting that part of the boundary layer under the continents. Previous solutions have noted that heat is lost from the Earth's interior by two mechanisms: an unsteady small-scale convection of sinking and rising jets transporting heat to the base of the lithosphere through which it is subsequently lost by conduction; and larger scale recirculation of the whole lithosphere in oceanic regions, that is, plate tectonics. The driving and resisting forces involved in the second mechanism are difficult to quantify and there has been a temptation to assume that plate tectonics can transport any necessary extra heat. Richter has developed regional models to try to account for heat lost by both mechanisms as a function of internal temperatures. He looks particularly at the interdependence of the mechanisms. All his models with thermal boundary-layer definitions for the lithosphere result in boundary-layer thermal gradients that in-